LS-114
W. Chou and Y. Jin
April 1988

IMPEDANCE STUDIES - PART 3
TRANSVERSE-LOSS COMPENSATION

An interesting phenomenon, which we noticed in calculating the loss factors of various discontinuities in the APS storage ring, was that the transverse losses of different structures may partially cancel each other. This will be called transverse-loss compensation in our later discussion. The occurrence of this compensation is simply due to the fact that the signs of the transverse losses play a role. We know that all kinds of discontinuities, except a few special cases, give the same sign to the longitudinal loss factor, which corresponds to an energy loss of the particle beam that passes through. By contrast, the transverse loss factors may have either a plus or a minus sign. In our notation, a plus sign means that the change of the transverse momentum of a beam is in the direction away from the central orbit (i.e., the wake force is defocusing), whereas a minus sign corresponds to an inward momentum change (i.e., a focusing wake force).

That the transverse losses may have different signs has been discussed earlier in the literature for some simple geometries. For example, Ref. 1 considered the case when a coasting beam passed through an elliptical beam chamber using an analytical method. However, this kind of discussion is impossible for more complicated structures without invoking numerical methods. The 3D code MAFIA allows for such an investigation. Table 1 is a list of the transverse-loss factors obtained from MAFIA for the following four different sorts of discontinuities: (1) a transition between the beam chamber and the insertion device (ID) section (Fig. 1), (2) a transition between the beam chamber and the RF section (Fig. 2), (3) a transition between the beam chamber with and without an antechamber (Fig. 3), and (4) a beam chamber with an antechamber and with a crotch absorber (Fig. 4). On the one hand, it is seen that both (1) and (2) give a positive loss in the vertical direction (defocusing) and a negative one in the horizontal direction (focusing), just as expected (Ref. 1). On the other hand, both (3) and (4) give transverse losses of just the opposite signs to the above (1) and (2). This means that a partial cancellation of the transverse losses would occur in the storage ring, according to the composition rule discussed in Ref. 2.

It should be pointed out that the results in Table 1 were obtained for a beam slightly displaced from the center of the beam chamber. It is conceivable, however, that the signs of the losses may change when displacement becomes large.

Although the losses of (3) and (4) are much smaller than those of (1) and (2), the total effect is not negligible, because a large number of discontinuities (3) and (4) exist in the APS storage ring (120 transitions of type (3) and 80 crotch absorbers). At the very least, one may assert that the antechamber and the crotch absorbers will not be harmful as far as the transverse beam stability is concerned. A pleasant surprise!

This transverse-loss compensation can be put to good use in various ways. For instance, one might intentionally design or add certain discontinuities in the storage ring such that the total transverse losses could be lowered. This will be discussed in a separate Light Source Note.

References

1. B. Zotter, Report CERN/ISR-TH/74-11.

2. W. Chou and Y. Jin, "Impedance Studies - Part 1: A Composition Rule," ANL Light Source Note LS-112 (April 1988).

Table 1

Transverse-Loss Factors Calculated by MAFIA*

No.	Structure	Vertical, $k_{\perp}^{(y)}$ (V/pC•m)	Horizontal, $k_{\perp}^{(x)}$ (V/pC•m)
1	Transition between beam chamber and ID section	34**	-2.2
2	Transition between beam chamber and RF section	19	-0.088
3	Transition between beam chamber with and without antechamber	-0.0006	0.0036
4	Beam chamber with antechamber and with crotch absorber	-0.0013	0.0076

* RMS bunch length σ = 1.75 cm.

**This number is obtained from TBCI. The MAFIA output for this parameter is under testing.

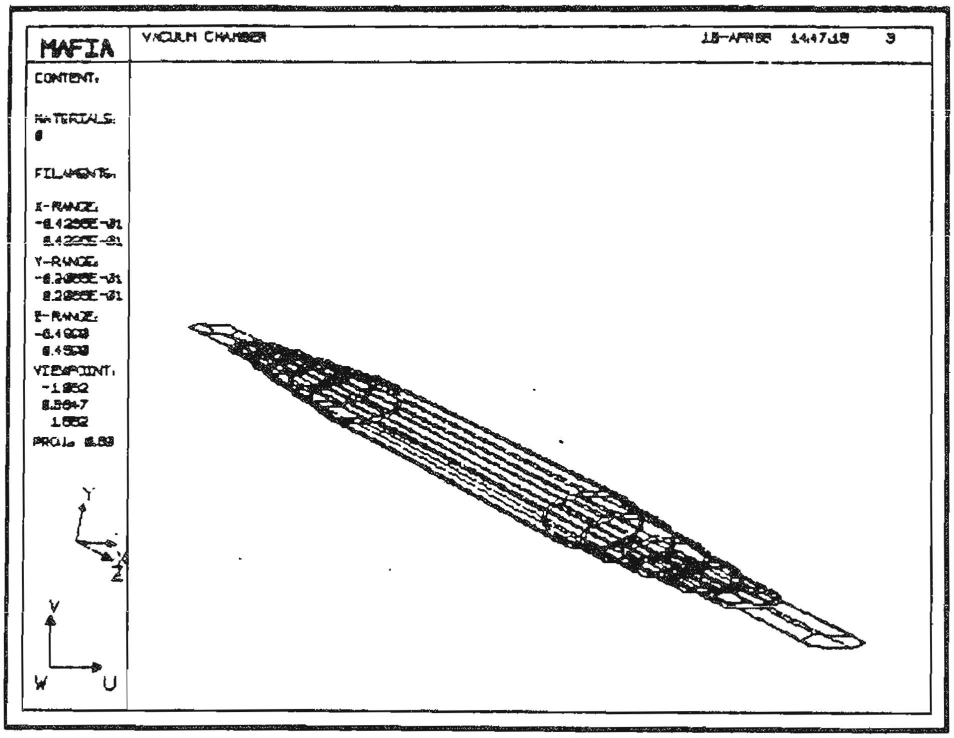

Fig. 1. A transition between the beam chamber and the ID section.

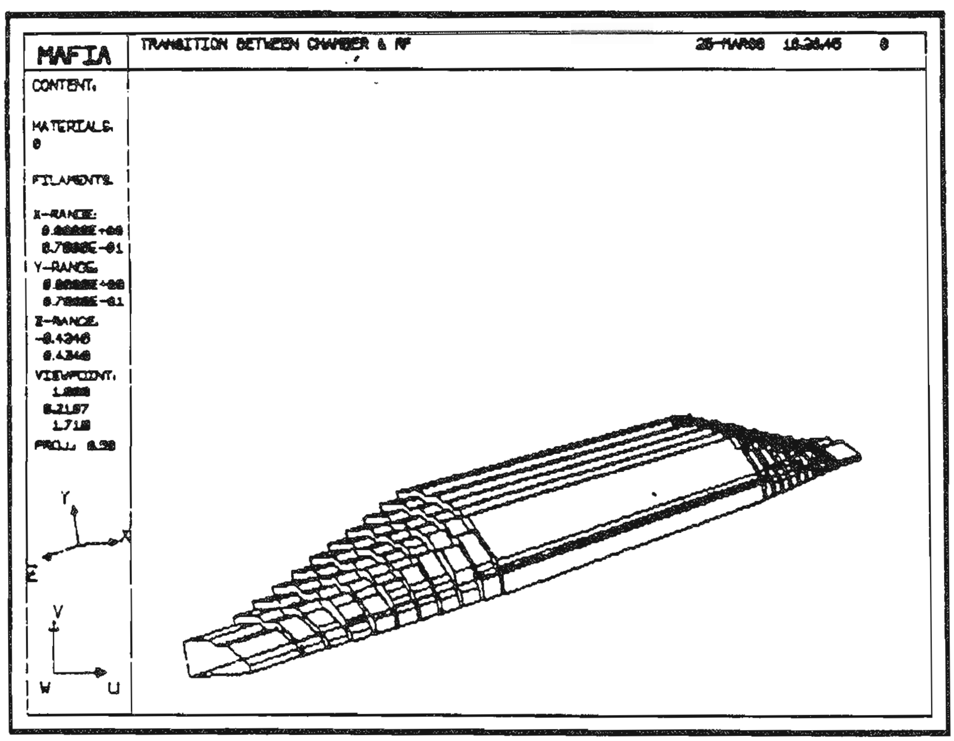

Fig. 2. A transition between the beam chamber and the RF section (a quarter of the structure).

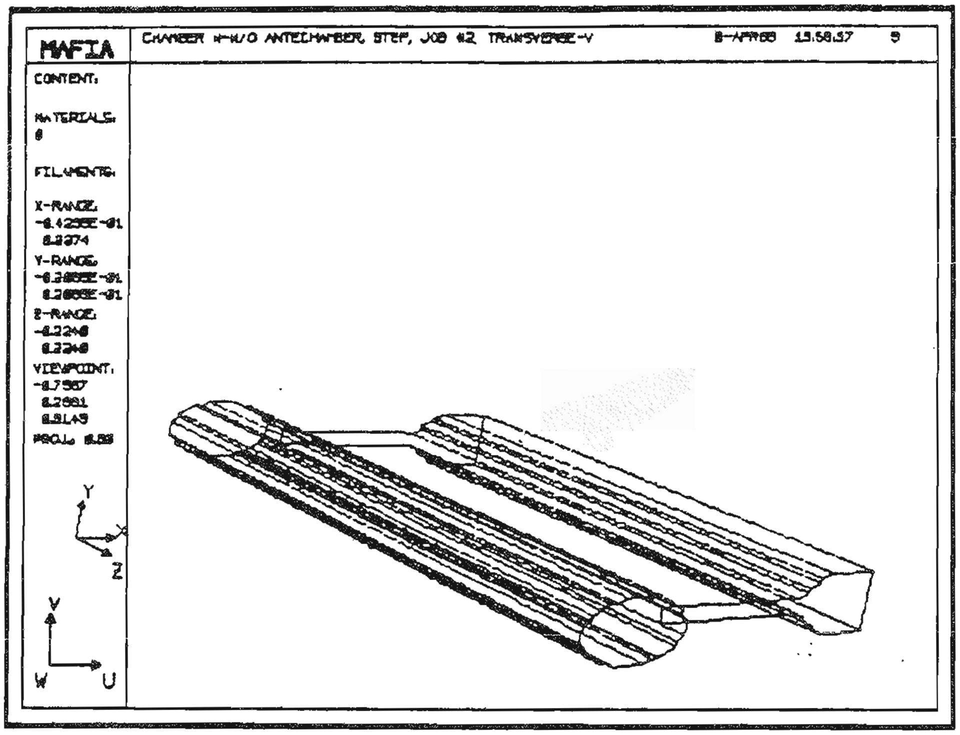

Fig. 3. A transition between the beam chamber with and without an antechamber.

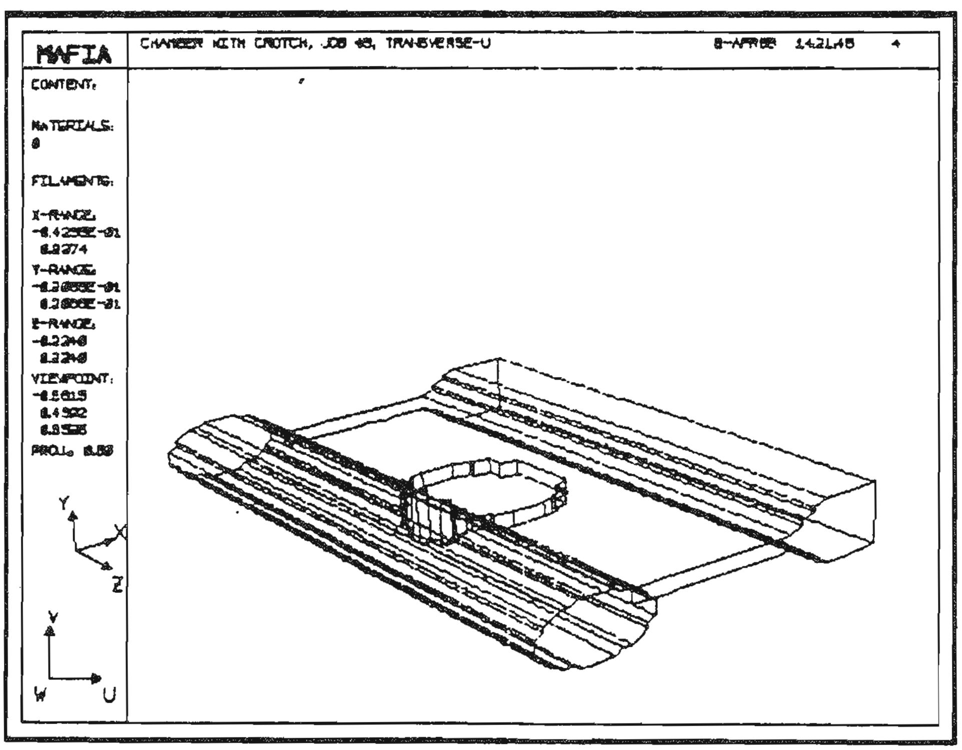

Fig. 4. A beam chamber with an antechamber and with a crotch absorber.